Designation: B 709 – 98

Standard Specification for Iron-Nickel-Chromium-Molybdenum Alloy (UNS N08028)* Plate, Sheet, and Strip[1]

This standard is issued under the fixed designation B 709; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers iron-nickel-chromium-molybdenum alloy (UNS N08028)* plate, sheet, and strip in the solution-annealed condition.

1.2 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

B 880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys[2]

E 8 Test Methods for Tension Testing of Metallic Materials[3]

E 10 Test Method for Brinell Hardness of Metallic Materials[3]

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[3]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[4]

E 38 Methods for Chemical Analysis of Nickel-Chromium and Nickel-Chromium-Iron Alloys[5]

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition[6]

E 140 Hardness Conversion Tables for Metals[3]

E 1473 Test Methods for Chemical Analysis of Nickel, Cobalt, and High-Temperature Alloys[7]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.2 The terms of plate, sheet, and strip as used in this specification are described as follows:

3.3 *plate*—material 0.187 in. (4.76 mm) and over in thickness and over 10 in. (254 mm) in width.

3.4 *sheet*—material under 0.187 in. (4.75 mm) in thickness and over 24 in. (610 mm) in width.

3.5 *strip*—material under 0.187 in. (4.75 mm) in thickness and under 24 in. (610 mm) in width.

4. Ordering Information

4.1 It is the responsibility of the purchaser to specify all requirements that are necessary for the safe and satisfactory performance of material ordered under this specification. Examples of such requirements include, but are not limited to the following:

4.1.1 Quantity (weight or number of pieces),

4.1.2 Name of material or UNS N08028,

4.1.3 Form (plate, sheet, or strip),

4.1.4 Dimensions,

4.1.5 Type of edge required (for strip only, see 8.4),

4.1.6 *Finish* (Section 9)—For sheet ordered with No. 4 finish, specify whether one or both sides are to be polished,

4.1.7 ASTM designation and year of issue,

4.1.8 *Marking*—State if metal die identification is required on plate ¼ in. (6.35 mm) or thicker (Section 17),

4.1.9 *Certification or Test Reports*—State if certification or test reports are required (Section 16), and

4.1.10 *Source Inspection*—State if inspection is required (Section 14).

5. Materials and Manufacture

5.1 *Heat Treatment*— The final heat treatment shall be a solution-anneal. Minor cold working such as flattening or temper rolling may be performed after the final solution annealing treatment.

NOTE 1—This recommended solution-anneal consists of heating to a minimum temperature of 1975°F (1080°C) and cooling rapidly to room temperature.

6. Chemical Composition

6.1 The material sampled in accordance with 11.2 shall conform to the composition limits prescribed in Table 1.

[1] This specification is under the jurisdiction of ASTM Committee B-2 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.07 on Refined Nickel and Cobalt and Their Alloys.

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* New designation in accordance with ASTM E 527 and SAE J1086, Practice for Numbering Metals and Alloys (UNS).

[2] *Annual Book of ASTM Standards*, Vol 02.04.

[3] *Annual Book of ASTM Standards*, Vol 03.01.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] Discontinued—See *1989 Annual Book of ASTM Standards*, Vol 03.05.

[6] *Annual Book of ASTM Standards*, Vol 03.05.

[7] *Annual Book of ASTM Standards*, Vol 03.06.

6.2 If a product analysis is subsequently made, the material shall conform to the composition limits with the product analysis variation prescribed B 880.

7. Mechanical Properties

7.1 The material shall conform to the requirements as to the mechanical property prescribed in Table 2.

8. Dimensions and Permissible Variations

8.1 *Sheet*—The material referred to as sheet shall conform to the variations in dimensions prescribed in Tables 3-8, inclusive.

8.2 *Cold-Rolled Strip*—The material referred to as cold-rolled strip shall conform to the permissible variations in dimensions prescribed in Tables 9-12 inclusive.

8.3 *Plate*—The material referred to as plate shall conform to the permissible variations in dimensions prescribed in Tables 13-19, inclusive.

8.4 *Edges for Cold-Rolled Strip*—The various types of edges procurable shall be as follows:

8.4.1 *No. 1. Edge*— Rolled edge, contour as specified.

8.4.2 *No. 3 Edge*—An edge produced by slitting.

8.4.3 *No. 5 Edge*—Approximately square edge produced by rolling or filing, or both, after slitting.

9. Workmanship, Finish, and Appearance

9.1 The material shall be free of injurious imperfections and shall correspond to the designated finish as described as follows:

9.1.1 *Sheet*—The various types of finish procurable on sheet products shall be as follows:

9.1.1.1 *No. 1 Finish*— Hot-rolled, annealed, and descaled; produced by hot rolling to specified thicknesses followed by annealing and descaling (see 10.2).

9.1.1.2 *No. 2D Finish*— Dull, cold-rolled finish; produced by cold rolling to the specified thickness, annealing and descaling. The dull finish results from the descaling and pickling operations.

9.1.1.3 *No. 2B Finish*— Bright, cold-rolled finish; produced by giving a final light cold-rolled pass with polished rolls, to a sheet that has been annealed and descaled.

9.1.1.4 *No. 4 Finish*— General-purpose polished finish. Following initial grinding with coarser abrasives, sheets are generally finished last with abrasives approximately 120 to 150 mesh. Sheets can be produced with one or two sides polished. When polished on one side only, the other side may be rough ground in order to obtain the necessary flatness.

9.1.1.5 *Bright Annealed*— Bright finish produced by cold rolling to thickness, then annealing in a protective atmosphere.

9.1.2 *Strip*—The type of finish procurable on cold-rolled strip shall be as follows:

9.1.2.1 *No. 1 Finish*— Cold-rolled to specified thickness annealed and pickled (see 10.2). Appearance of this finish is a dull gray.

9.1.2.2 *No. 2 Finish*— Same as No. 1 finish, followed by a final light cold-rolled pass, generally on highly polished rolls.

9.1.2.3 *Bright-Annealed*— Bright finish produced by cold-rolling to thickness, then annealing in a protective atmosphere.

9.1.3 *Plate*—The types of finish procurable on plates shall be as follows:

9.1.3.1 *Hot- or Cold-Rolled, Annealed*—Scale not removed.

9.1.3.2 *Hot- or Cold-Rolled, Annealed, Descaled*—Scale removed by a blast cleaning or pickling operation.

9.2 Spot grinding to remove surface imperfections is permitted, provided such grinding does not reduce the thickness or width at any point beyond the permissible variations in dimensions.

10. Sampling

10.1 *Lot for Chemical Analysis, Mechanical Testing, and Corrosion Testing*:

10.1.1 A lot for chemical analysis shall consist of one heat.

10.1.2 *Plate*—A lot of plate for testing and inspection purposes shall consist of the products resulting from the rolling of one heat of material in the same condition and specified thickness, solution annealed by the same practice, but in no case more than 25 000 lb (11 340 kg).

10.1.3 *Sheet and Strip*— A lot of sheet or strip for testing and inspection purposes shall consist of material from one heat in the same form (sheet or strip), condition, finish, and specified thickness, solution-annealed by the same practice but in no case more than 25 000 lb (11 340 kg).

10.2 *Sampling of Chemical Analysis*:

10.2.1 A representative sample shall be taken from each lot during pouring or subsequent processing.

10.2.2 Product analysis, if performed, shall be wholly the responsibility of the purchaser.

10.3 *Sampling for Mechanical Tests*:

10.3.1 A sample of the material to provide test specimens for mechanical tests shall be taken from such a location in each lot as to be representative of that lot.

10.3.2 When samples are to be taken after delivery, the purchaser of material ordered to cut lengths may request on the purchase order additional material of adequate size to provide sample coupons for inspection purposes.

11. Number of Tests and Retests

11.1 In the case of sheet or strip supplied in coil form, two or more tension tests (one from each end of each coil), and one or more hardness tests shall be made on specimens taken from each end of the coil. When material is supplied in flatsheet, flat strip, or plate, one tension and one or more hardness tests shall be made on each 100 or less sheets, strips, or plates of the same lot. When specified, one corrosion test shall be conducted for each lot.

11.2 If any specimens selected to represent any lot fail to meet any of the test requirements, the material represented by such specimens may be retested. If there is valid reason to believe the result is not representative, the material may be re-reannealed and retested.

12. Specimen Preparation

12.1 Tension test specimens from material under ½ in. (12.7 mm) in thickness shall be of the full thickness of thematerial and machined to the form and dimensions shown for the sheet-type specimen in Test Methods E 8. Tension test specimens from material ½in. (12.7 mm) and over shall be of the

full thickness of the material, machined to the form and dimensions shown for the plate-type specimen in Test Methods E 8. Tension test specimens shall be taken from material after final heat treatment and shall be selected in the transverse direction unless prohibited by width.

13. Test Methods

13.1 Determine the chemical composition and properties of the material as enumerated in this specification, in case of disagreement, in accordance with the following methods:

Test	ASTM Designations
Chemical analysis	E 38, E 1473[A,B]
Tension	E 8
Brinell hardness	E 10
Rockwell hardness	E 18
Hardness conversion	E 140
Rounding procedure	E 29
Method of sampling for product analysis	E 55

[A] Iron shall be determined arithmetically by difference.
[B] Methods E 38 are to be used only for elements not covered by Test Methods E 1473.

13.2 For purpose of determining compliance with the limits in this specification, an observed value or a calculated value shall be rounded as indicated in accordance with the rounding method of Practice E 29.

Requirements	Rounded Unit for Observed or Calculated Value
Chemical composition hardness and tolerance (when expressed in decimals)	nearest unit in the last right-hand place of figures of the specified limit
Tensile strength and yield strength	nearest 1000 psi (7 MPa)
Elongation	nearest 1 %

14. Inspection

14.1 Inspection of the material by the purchaser shall be made as agreed upon between the purchaser and the manufacturer as set forth in the purchase contract.

15. Rejection and Rehearing

15.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

16. Certification

16.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

17. Product Marking

17.1 Each piece (plate, sheet, strip, or coil) shall be marked legibly with the specification number, UNS number, heat number and the name of the manufacturer. When specified, marking shall be by die stamping on plates ¼ in. (6.35 mm) or thicker.

TABLE 1 Chemical Requirements

Element	Composition, %
Ni	29.5 to 32.5
Fe	remainder[A]
Cr	26.0 to 28.0
Mo	3.0 to 4.0
C, max	0.030
Si, max	1.00
Mn, max	2.50
P, max	0.030
S, max	0.030
Cu	0.6 to 1.4

[A] Determined arithmetically by difference.

TABLE 2 Mechanical Property Requirements

Form	Tensile Strength, min, ksi (MPa)	Yield Strength (0.2 % offset), min, ksi (MPa)	Elongation in 2 in. or 50 mm, or 4D, min, %	Rockwell Hardness (or equivalent)[A]
Sheet	73 (500)	31 (214)	40	70–90 HRB
Strip	73 (500)	31 (214)	40	70–90 HRB
Plate	73 (500)	31 (214)	40	70–90 HRB

[A]Hardness values are shown for information only and shall not constitute a basis for acceptance or rejection as long as the other mechanical properties are met.

TABLE 3 Thickness Tolerances for Hot-Rolled and Cold-Rolled Sheets

Specified Thickness, in. (mm)	Tolerance, over and under, in. (mm)
Over 0.145 to less than 0.187 (3.68 to less than 4.76)	0.014 (0.36)
Over 0.130 to 0.145 (3.30 to 3.68), incl	0.012 (0.30)
Over 0.114 to 0.130 (2.90 to 3.30), incl	0.010 (0.25)
Over 0.098 to 0.114 (2.49 to 2.90), incl	0.009 (0.23)
Over 0.083 to 0.098 (2.11 to 2.49), incl	0.008 (0.20)
Over 0.072 to 0.083 (1.83 to 2.11), incl	0.007 (0.18)
Over 0.058 to 0.072 (1.47 to 1.83), incl	0.006 (0.15)
Over 0.040 to 0.058 (1.02 to 1.47), incl	0.005 (0.13)
Over 0.026 to 0.040 (0.66 to 1.02), incl	0.004 (0.10)
Over 0.016 to 0.026 (0.41 to 0.66), incl	0.003 (0.08)
Over 0.007 to 0.016 (0.18 to 0.41), incl	0.002 (0.05)
Over 0.005 to 0.007 (0.13 to 0.18), incl	0.0015 (0.04)
0.005 (0.13)	0.001 (0.03)

TABLE 4 Width and Length Tolerances for Hot-Rolled and Cold-Rolled Resquared Sheets (Stretcher Leveled Flatness)

Specified Dimensions, in. (mm)	Tolerance, in. (mm)	
	Over	Under
For thicknesses under 0.031 (0.79):		
Widths up to 48 (1219), excl	1/16(1.6)	0
Widths 48 (1219) and over	1/8(3.2)	0
Lengths up to 120 (3048), excl	1/16 (1.6)	0
Lengths 120 (3048) and over	1/8(3.2)	0
For thicknesses 0.031 (0.79) and over:		
All widths and lengths	1/4(6.4)	0

TABLE 5 Width, Length, and Camber Tolerances for Hot-Rolled and Cold-Rolled Sheets Not Required

Width Tolerances		
Specified Thickness, in. (mm)	Tolerance for Specified Width, in. (mm)	
	24 to 48 (610 to 1219), excl	48 (1219) and over
Less than 3/16 (4.76)	1/16 (1.6) over, 0 under	1/8(3.2) over, 0 under
Length Tolerances		
Specified Length, ft (mm)	Tolerance, in. (mm)	
	Over	Under
Up to 10 (3050), incl	1/4 (6.4)	0 (0)
Over 10 to 20 (3050 to 6100), incl	1/2 (12.7)	0 (0)
Camber Tolerances[A]		
Specified Width, in. (mm)	Tolerance per Unit Length of any 8 ft (2440 mm), in. (mm)	
24 to 36 (610 to 914), incl	1/8 (3.2)	
Over 36 (914)	3/32(2.4)	

[A]Camber is the greatest deviation of a side edge from a straight line, and measurement is taken by placing an 8-ft (2440-mm) straightedge on the concave side and measuring the greatest distance between the sheet edge and the straight edge.

TABLE 6 Flatness Tolerances for Hot-Rolled and Cold-Rolled Sheets

Sheets not Specified to Stretcher Leveled Standard of Flatness		
Specified Thickness, in. (mm)	Width, in. (mm)	Flatness Tolerance (max Deviation from a Horizontal Flat Surface), in. (mm)
0.062 (1.57) and over	to 60 (1524), incl	1/2 (12.7)
	over 60 to 72 (1524 to 1829), incl	3/4 (19.1)
	over 72 (1829)	1 (25.4)
Under 0.062 (1.57)	to 36 (914), incl	1/2(12.7)
	over 36 to 60 (914 to 1524), incl	3/4 (19.1)
	over 60 (1524)	1 (25.4)

Sheets Specified to Stretcher Level Standard of Flatness			
Specified Thickness, in. (mm)	Width, in. (mm)	Length, in. (mm)	Flatness Tolerance, in. (mm)
Under 3/16 (4.76)	to 48 (1219), incl	to 96 (2438), incl	1/8(3.2)
Under 3/16 (4.76)	to 48 (1219), incl	over 96 (2438)	1/4(6.4)
Under 3/16 (4.76)	over 48 (1219)	to 96 (2438), incl	1/4(6.4)
Under 3/16 (4.76)	over 48 (1219)	over 96 (2438)	1/4(6.4)

TABLE 7 Diameter Tolerances for Hot-Rolled and Cold-Rolled Sheets, Sheared Circles

Specified Thickness, in. (mm)	Tolerance over Specified Diameter (No Tolerance Under), in. (mm)		
	Under 30 (762)	30 to 48 (762 to 1219), incl	Over 48 (1219)
Over 0.097 (2.46)	1/8 (3.2)	3/16(4.8)	1/4 (6.4)
Over 0.057 to 0.097 (1.45 to 2.46), incl	3/32 (2.4)	5/32(4.0)	7/32 (5.6)
0.057 (1.45) and under	1/16(1.6)	1/8 (3.2)	3/16 (4.8)

TABLE 8 Weight Tolerances for Hot-Rolled and Cold-Rolled Sheets

It is not practicable to produce hot-rolled and cold-rolled sheets to exact theoretical weight. Sheets of any one item of a specified thickness and size in any finish may be overweight to the following extent:

(*1*) An item of five sheets or less, or an item estimated to weigh 200 lb (90.7 kg) or less, may actually weigh as much as 10 % over the theoretical weight.

(*2*) An item of more than five sheets and estimated to weigh more than 200 lb (90.7 kg) may actually weigh as much as 7½ % over the theoretical weight.

(*3*) The underweight variations for sheets are limited by the under thickness tolerances shown in Table 3.

For determining theoretical weight, the factor 42 lb/ft^2·in. (0.0008 kg/cm^2·mm) thickness may be used.

TABLE 9 Thickness Tolerance[A,B,C] for Cold-Rolled Strip for the Thicknesses and Widths Given, Over and Under

Specified Thickness	Width, in.							
	0.187 to 1, incl	Over 1 to 3, incl	Over 3 to 6, incl	Over 6 to 9, incl	Over 9 to 12, incl	Over 12 to 16, incl	Over 16 to 20, incl	Over 20 to 24, incl
	Thickness Tolerance, in.							
Over 0.160 to less than 0.187	0.002	0.003	0.004	0.004	0.004	0.005	0.006	0.006
Over 0.099 to 0.160, incl	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.005
Over 0.068 to 0.099, incl	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004
Over 0.049 to 0.068, incl	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004
Over 0.039 to 0.049, incl	0.002	0.002	0.0025	0.003	0.003	0.003	0.004	0.004
Over 0.034 to 0.039, incl	0.002	0.002	0.0025	0.0025	0.003	0.003	0.003	0.003
Over 0.028 to 0.034, incl	0.0015	0.0015	0.002	0.002	0.0025	0.0025	0.003	0.003
Over 0.025 to 0.028, incl	0.001	0.0015	0.0015	0.002	0.002	0.002	0.0025	0.003
Over 0.019 to 0.025, incl	0.001	0.001	0.0015	0.0015	0.002	0.002	0.0025	0.0025
Over 0.016 to 0.019, incl	0.001	0.001	0.001	0.0015	0.0015	0.002	0.002	0.002
Over 0.012 to 0.016, incl	0.001	0.001	0.001	0.001	0.0015	0.0015	0.002	0.002
Over 0.011 to 0.012, incl	0.001	0.001	0.001	0.001	0.0015	0.0015	0.0015	0.0015
Over 0.010 to 0.011, incl	0.001	0.001	0.001	0.001	0.001	0.0015	0.0015	0.0015
0.010	0.001	0.001	0.001	0.001	0.001	0.001	0.0015	0.0015

Specified Thickness, mm	Width, mm							
	4.76 to 25.4, incl	Over 25.4 to 76.2, incl	Over 76.2 to 152.4, incl	Over 152.4 to 228.6, incl	Over 228.6 to 304.8, incl	Over 304.8 to 406.4, incl	Over 406.4 to 508, incl	Over 508 to 609.6, incl
	Thickness Tolerance, mm							
Over 4.06 to less than 4.76	0.05	0.08	0.10	0.10	0.10	0.13	0.15	0.15
Over 2.51 to 4.06, incl	0.05	0.05	0.08	0.08	0.10	0.10	0.13	0.13
Over 1.73 to 2.51, incl	0.05	0.05	0.08	0.08	0.08	0.10	0.10	0.10
Over 1.25 to 1.73, incl	0.05	0.05	0.08	0.08	0.08	0.08	0.10	0.10
Over 0.99 to 1.24, incl	0.05	0.05	0.06	0.08	0.08	0.08	0.10	0.10
Over 0.86 to 0.99, incl	0.05	0.05	0.06	0.06	0.08	0.08	0.08	0.08
Over 0.71 to 0.86, incl	0.04	0.04	0.05	0.05	0.06	0.06	0.08	0.08
Over 0.64 to 0.71, incl	0.02	0.04	0.04	0.05	0.05	0.05	0.06	0.08
Over 0.48 to 0.64, incl	0.02	0.02	0.04	0.04	0.05	0.05	0.06	0.06
Over 0.41 to 0.48, incl	0.02	0.02	0.02	0.04	0.04	0.05	0.05	0.05
Over 0.38 to 0.41, incl	0.02	0.02	0.02	0.02	0.04	0.04	0.05	0.05
Over 0.28 to 0.30, incl	0.02	0.02	0.02	0.02	0.04	0.04	0.04	0.04
Over 0.25 to 0.28, incl	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.04
0.25	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.04

[A] For thickness under 0.010 to 0.005 in. (0.254 to 0.127 mm), inclusive, in widths up to and including 16 in. (406 mm), a tolerance of ±10 % of the thickness applies. For thicknesses under 0.010 to 0.005 in. (0.254 to 0.127 mm), inclusive, in widths over 16 to 24 in. (406 to 610 mm), exclusive, a tolerance of ±15 % of the thickness applies. For thickness tolerances on thicknesses under 0.005 in. (0.127 mm) in widths up to 24 in. (610 mm), exclusive, the producer should be consulted.

[B] Thickness measurements are taken ⅜ in. (9.5 mm) in from the edge of the strip, except that on widths less than 1 in. (25.4 mm) the tolerances are applicable for measurements at all locations.

[C] The tolerances in this table do not include crown tolerances.